

## REMEDATION

## Can Transgenic Plants Root Out Pollutants?

A team of researchers at Colorado State University in Fort Collins and Duke University in Durham, North Carolina, have created transgenic plants that turn from green to white when exposed to the explosive 2,4,6-trinitrotoluene (TNT).<sup>1</sup> Ultimately, the researchers hope, several simple and affordable plants will be developed that can quickly sense a variety of biological and chemical agents.

The research team combined genes from bacteria and plants to construct a modular “de-greening” gene circuit that breaks down chlorophyll, the green pigment in plants, while simultaneously preventing chlorophyll biosynthesis. The gene circuit contains a customized receptor for a specific hazardous agent—in this case, TNT. When the receptor binds its target, it triggers the de-greening reaction.<sup>1</sup> “The modular circuit can be inserted into any plant,” says study leader June Medford, a biology professor at Colorado State University.

In the new study, transgenic *Arabidopsis* and tobacco plants turned white when they contacted airborne TNT or when exposed to soilborne TNT through their roots. Second-generation plants grown from seeds of the first plants inherited the ability to sense and respond to TNT.<sup>1</sup> The color conversion in the laboratory plants took 2 to 3 hours. Medford’s team is working to reduce the response time to minutes rather than hours.

Just picomolar (ppt) or nanomolar (ppb) levels of TNT activated the de-greening process, suggesting the system is feasible for real-world applications.<sup>1</sup> Dogs trained to sniff out explosives and drugs generally discern these agents at ppb or ppt concentrations.<sup>2,3</sup>

The plant technology could be deployed “along travel routes to detect for improvised explosive devices or on training ranges to monitor for TNT contamination in soil or runoff,” says Linda Chrisey, biotechnology program manager at the Office of Naval Research in Arlington, Virginia. According to the Agency for Toxic Substances and Disease Registry, TNT contamination is found on at least 20 National Priorities List sites identified by the U.S. Environmental Protection Agency.<sup>4</sup> People can be exposed to TNT through eating, drinking, touching, or inhaling contaminated soil, water, food, or air, with potential health effects including anemia, abnormal liver function, skin irritation, and cataracts.<sup>4</sup>

Transgenic sentinel plants should not face disposal concerns, because they do not become chemically saturated, according to Medford. “This is not phytoremediation; we’re talking about exceeding low levels of contaminants,” she says. Moreover, she says, “We don’t intend to put this technology into plants that people eat.”

“This is a revolutionary approach to working with plants as environmental sentinels that looks to have broad application,” says Bill Farland, senior vice president for research at Colorado State University. For instance, plants may someday sniff out air or water pollutants released from industrial sources such as chemical manufacturing plants. Other potential applications, Chrisey notes, include the detection of herbicides on crops, pathogens in municipal water supplies, or explosives in airports.

“We still have to explore all the possibilities of chemicals that could be sensed by plants,” Farland says. The key lies in designing a receptor for a pollutant of choice and engineering it into the plant de-greening circuit. Medford’s team also is designing plants with multiple receptors to detect more than one pollutant.

## The Beat

by Erin E. Dooley

### NTP Issues Draft Report on Aloe Vera

Many aloe beverages on the market today are made with decolorized aloe, in which charcoal filtration removes biochemical components such as aloin, a suspected carcinogen and one of the anthraquinones thought to give the plant its laxative properties. However, a



Aloe vera juice is marketed as a laxative and digestive tonic.

lack of federal labeling requirements means consumers cannot be sure whether or how much aloin is present in any given product. In response to health concerns about aloin and other aloe constituents, the National Toxicology Program (NTP) recently completed a 2-year rodent assay of nondecolorized extract of aloe vera (derived from the green part of the leaf as opposed to the clear gel inside).<sup>1</sup> The program’s draft report, issued in April, concludes that rats given water containing 60 ppm aloin—6 times the amount allowed in orally ingested products under self-imposed industry standards—39% of females and 74% of males developed malignant or benign intestinal tumors. The human health implications of these findings are unclear. A final NTP report is expected in 2012.

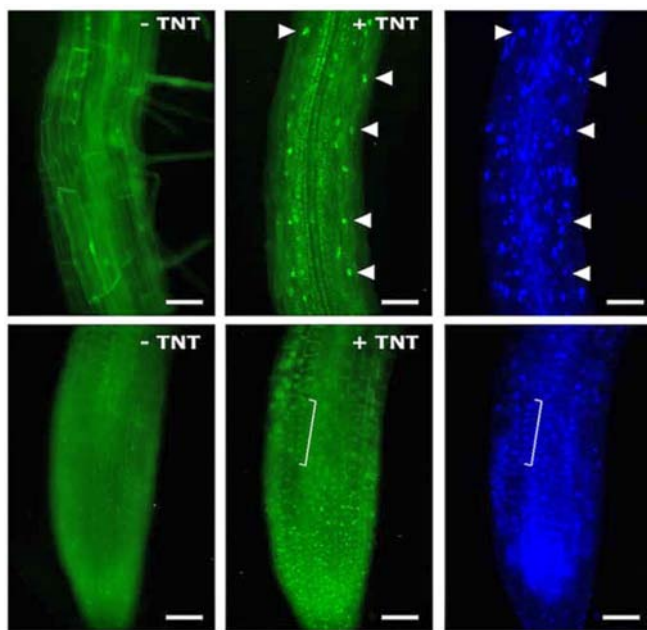
### OSHA Issues Alert on Formaldehyde in Hair-Straightening Products

As a result of concerns from salon employees, federal and state officials

are investigating worker exposures to formaldehyde during use of hair-straightening products, some of which contain the chemical without listing it on the label. One investigation documented air levels of formaldehyde in excess of OSHA limits for salons even though the product used was labeled “formaldehyde-free.” In April 2011 OSHA issued a hazard alert to warn salon owners and workers about the potential health effects of formaldehyde, ways to determine if products contain the chemical, and steps to reduce exposure.<sup>2</sup> Formaldehyde, a known human carcinogen, can also irritate the nose and eyes and cause adverse allergic and neurologic effects.<sup>3</sup>

### Global Study Finds cVMS Widely Distributed in Air

cVMS, or cyclic volatile methyl siloxanes, are high-production-volume chemicals used in personal care products to make them feel silky and to help them dry quickly. A new study of cVMS in ambient air found



Epifluorescence images of different portions of transgenic *Arabidopsis* roots shown before and after addition of the TNT ligand. Far right panels show DAPI nuclear staining. Arrowheads indicate nuclei. Scale bar = 25  $\mu$ m.

“Living organisms have advantages as sentinels of pollution,” says Paul Johnson, a professor of physics and astronomy at the University of Wyoming in Laramie. In 2009 he and colleagues

in France reported they had genetically engineered tadpoles to detect zinc in water with a portable, flow-through system.<sup>5</sup> Like Medford’s plants, the transgenic tadpoles carry a receptor for a selected pollutant that triggers fluorescence in about an hour. Also, tadpoles are being designed to detect more than one environmental pollutant—potentially to include heavy metals, organochlorine pesticides, bisphenol A, polychlorinated biphenyls, and dioxins—and to generate several fluorescent colors.<sup>6</sup>

Plants and tadpoles provide relatively cheap monitoring systems, Johnson says, and they give results rapidly onsite, compared with carrying samples back to a laboratory for expensive analysis such as mass spectrometry. Plus, he says, living systems, particularly animal-based ones, reflect physiologic effects of environmental pollutants similar to those that occur in humans. “The detection of contaminants and pollutants in air and water is a rapidly expanding area, and new developments will stay fruitful for a long time,” Johnson says.

**Carol Potera**, based in Montana, has written for EHP since 1996. She also writes for *Microbe*, *Genetic Engineering News*, and the *American Journal of Nursing*.

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- After use the tadpoles are euthanized, then disposed of under the same guidelines as laboratory cell culture media. They are contained in a closed tank and are not released into the wild.

the compounds clustered in varying distributions at each of 20 sites around the world, including 5 Arctic sites.<sup>4</sup> The D5 and D6 species of cVMS concentrated in the urban sites studied, whereas the D3 and D4 species were especially elevated along the U.S. West Coast. D5 and D6 are the cVMS used most commonly in personal care products, while D3 and D4 are thought to be associated with industries that produce silicone polymers. Currently there are no restrictions on any use of cVMS, but regulators in a number of countries are paying more attention to these compounds because of evidence they may be persistent, bioaccumulative, and toxic.

## EPA Warns of Illegal Pesticide Sales Online

In April 2011 the U.S. EPA announced it had warned almost 3,000 customers across the country about Fast Ant Bait products they had purchased online.<sup>5</sup> The products contain mirex, a pesticide



banned since 1978 because of its adverse liver, skin, reproductive, and neurologic effects.<sup>6</sup> When EPA officials discovered the products were being sold online, they ordered the online payment company to cease processing orders for the Chinese-made and -distributed products. The EPA

notified U.S. customers about the health risks posed by the products and how to properly clean up and dispose of them. Canada’s Pest Management Regulatory Agency has notified customers in that country as well.

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